# The State of Science, Technology, Engineering and Mathematics (STEM) Education Reform in Alabama

## Executive Summary

*"Long range planning does not deal with future decisions,*

*but with the future of present decisions"* --- Peter Drucker

In his 2001 "No Child Left Behind" legislation, President George W. Bush stated, "Bipartisan education reform will be the cornerstone of my administration." In reconciling the State of Alabama educational challenges with the President's plans for education reform, the Alabama Mathematics, Science, and Technology Education Coalition (AMSTEC) has developed a strategic plan for researching, designing, and implementing a new education model for systemic STEM education reform.

The challenges in Alabama's STEM education reform are not new. Differences in ethnicity, gender, and socio-economic status, which are among the primary indices for evaluating educational literacy, have proven that education reform must be mandatory to ensure that no child is left behind. According to President Bush, "Too many children in America are segregated by low expectations, illiteracy, and self-doubt. In a constantly changing world that is demanding increasingly complex skills from its workforce, children are literally being left behind." Systemic education reform is tantamount to achieving academic excellence for disadvantaged students, boosting teacher quality, ensuring safe schools, and encouraging freedom and accountability.

AMSTEC and the State of Alabama have existing programs and initiatives to build upon in this effort; everyone has a part to play. AMSTEC's role is to redefine and refine what those jobs are and to communicate that across the stakeholder community. In the 2004 State of the Union address, President Bush announced Jobs for the 21st Century – a comprehensive plan to prepare workers better for jobs in the new millennium by strengthening post secondary education and job training and improving high-school education. This white paper addresses that call for Alabama's K-20 classrooms and describes the state of STEM education and plans for its continued growth. It encourages you to support systemic STEM education reform legislation and describes the advantages of transitioning from traditional classroom rote instruction to inquiry-based teaching and learning.

This fundamental shift in education methodology is critical to the future of science, technology, engineering, and math (STEM) because it will:

1. Enable K-20 students to understand how embracing a new learning style will lead to better education.
2. Enable teachers to share information in a way that fosters enhanced communication and deep content retention and become a "guide on the side" rather than a "sage on the stage".
3. Create a scientifically literate populace that uses inquiry and logical deduction as a primary method of problem solving.
4. Provide a well-educated workforce that will lead, rather than follow, ecological, technological, and economical change.

With these ideals in mind, we must change the way in which we teach and learn. We must provide an equitable solution to an age-old problem. We must support education reform legislation. We must create an environment to ensure the continued success of the United States as a world leader in many areas, including STEM education. We must look for ways to include business and industry in the solutions and we must foster community and family programs that support systemic STEM education reform in Alabama.

The Governor's Commission on Education Spending concludes its January 14, 2004 report with the recommendation that "any additional revenues … be invested to bring the greatest improvements in education achievement and economic development for the State of Alabama, including the:

- Alabama Reading Initiative
- Alabama Math, Science, and Technology Initiative
- Implementation of an improved accountability system for K-12 and improved assessment of student progress toward education goals
- Creation of incentive funds for post secondary and higher education tied to high-priority state goals for workforce development, research, instruction and economic development."

AMSTEC supports these recommendations. The programs and initiatives described in this paper are aligned also with the Governor's new plan for an Alabama Space Exploration Initiative. They provide a mechanism for supporting NASA's new vision in space exploration, and ultimately for positioning Alabama as a leader in systemic STEM education reform. Finally, AMSTEC and its partnership model for systemic STEM education reform is an implementation network for innovative workforce development programs that meet the needs and challenges of the 21st century marketplace.

# The State of Science, Technology, Engineering and Mathematics (STEM) Education Reform in Alabama

**By**

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**January 2004**

"Alabama has abundant blessings few states can rival. That has never been more true than today. From the port of Mobile, where revitalization is underway to open Alabama's door to the world, to the high-tech superiority of Huntsville, economic development opportunities abound. Today Alabama stands ready to take its place as a leader in our national economy and our national policy." (Governor Riley's opening State of the State address to the 2004 Legislative Session)

## What is systemic STEM education reform and where did it come from?

"Systemic STEM Education Reform" is the transition of resources, curricula, and instruction from classroom, rote memorization to hands-on, inquiry-based teaching and learning in Science, Technology, Engineering and Mathematics (STEM) for American schools from primary grades to graduate school (K-20). It is called "systemic" because it requires a change in the delivery of science, technology, engineering, and mathematics education at every level. This, in turn, requires a change in how it is delivered and implemented by the federal, state, and local entities charged with educating our citizens. It is called "reform" because it requires fundamental changes in educational delivery that may not be familiar to undergraduate STEM faculty and College of Education faculty or the K-12 classroom teacher. This is important since these two main groups are at the leading edge of STEM education implementation.

Since the first report was issued on the need to improve STEM education for reasons related to America's future as a world power (A Nation at Risk, 1983), the task of improving and delivering inquiry-based STEM education has been a challenging one. By the late 1980's, a proven teaching approach emerged that was promising and compelling because of its purported and documented improvements to learning. It was developed by education research organizations like the National Science Foundation (NSF) and the National Science Resources Center (NSRC), in conjunction with information learned from developmental psychology. Inquiry-based, hands-on teaching/learning was identified as a primary mechanism for instituting STEM education reform and for recognizing that change was occurring in classroom instruction (NRC, 2000).

Almost fifteen years later, and after additional well-documented education research that placed American student's assessment among the lowest in STEM performance compared with students in 41 other countries (TIMSS, 1999), awareness of the need for systemic STEM education reform implementation is gaining momentum. With the advent of the second generation of inquiry and research-based K-12 instructional materials – including kits of mathematics and science content with and without textbooks – states and districts continue to refine and improve STEM education delivery. Refining K-12 STEM curricula to meet the National Science Education Standards (NSES, 1996) and the National Council of Teachers of Mathematics Standards (NCTMS, 1989), which now provide a benchmark for evaluation through mandatory state and national assessments, has been coupled with an equally pressing need to improve teacher training.

Meeting the need for improved STEM professional development includes developing offerings for both in-service and pre-service teachers. Programs like the American Association for the Advancement of Science's Project 2061 (www.project2061.org) support the national standards, offer professional development for teachers, and have developed excellent tools like "Science for All Americans", "Benchmarks for Science Literacy", and "Atlas for Science Literacy" to assist in this process. The Glenn-Commission Report(2000) restated the importance of professional development for STEM teachers. The "No Child Left Behind" (NCLB, 2001) federal legislation and its call for "qualified teachers" re-emphasized the need to increase the number of STEM–trained teachers teaching within their area of expertise. But to achieve successful systemic STEM education reform, others have shown it important to partner with community-based businesses, industries, and families (Epstein, in press; Stephens and Scott, 2002).

The numbers of STEM professionals who are eligible for retirement from America's government and corporate workforce is growing each quarter. The need for strengthening STEM programs in career technical schools, in workforce development efforts like mentoring, retraining and certification, and in the higher education institutions (at both undergraduate and graduate levels), in systemic education reform is gaining attention from some of our nations top leaders (NSF, 2002 & 2003). In "Blueprint for Change: Report on the Revolution in Earth and Space Science Education," (TERC, 2002) a call for a science-literate citizenry is, once again, linked to maintaining American's national security and its position in science and technology leadership for the 21st century.

## WHY IS SYSTEMIC STEM EDUCATION REFORM IMPORTANT?

The goal of STEM education reform is to create a scientifically literate populace and a qualified workforce that can compete in the 21st century workplace (Hart-Rudman, 2001). To supply a qualified workforce to Alabama's prolific, high-technology businesses and industries, we must identify and fund the changes needed for STEM education reform. Alabama's success in attracting new business and retaining its industry affiliates and governmental contracts depends on its performance in STEM education reform and workforce development efforts. Astounding survey results performed by the Workforce Aging Management Program (WAMP) in neighboring Tennessee and North Alabama indicate that only less than 1% of career center applicants are qualified for technological jobs but that 2% are capable given additional retraining and certification.

The future success of Alabama's businesses and industries depends upon focusing on effective systemic STEM education reform and workforce development. A 2003 Economic Development Report Card (www.drc.org) press release for Alabama cites the following statistics used to formulate the state's scores across 68 measures of economic development success:

| | |
|---|---|
| Performance | F |
| Business Vitality | B |
| Development Capacity | F |

Alabama scored an F in its Development Capacity index indicating weak education. In one of the three main indices used to formulate state's scores, five out of 20 of Alabama's weakest measures were in the education arena: high school completion, high school attainment, college attainment, PhD scientists, engineers, and households with computers (Figure 1). The Governor's Office has taken steps to help Alabama's citizens stay abreast of changing technologies associated with employment more efficiently. The Office of Workforce Development was created and merged from seven other state agencies within which its functions were being performed. Both the report on Alabama's economic development opportunities and the reorganization and creation of the Office of Workforce Development are indicators to policymakers of the importance that systemic STEM education reform holds for our future.

Alabama's businesses parallel the Nation's with respect to calls for STEM education reform. The Business Council of Alabama's December 2003 report to the Governor

> "recommends the enactment of the provisions of Senate Bill 7, linked to Amendment 1, that offers salary supplements to highly qualified math, science, and special education teachers to work in under-performing or hard to staff rural and urban schools." (Executive Summary, pg. 11)

Evidence of industry's united acknowledgement of the need for systemic education reform and support for all schools, especially under-performing schools, is evident at the national level too. On January 7th 2004, the Business Roundtable, along with leaders of 11 major business organizations, sent a letter to all members of congress. They support education reform as it relates to implementing the "No Child Left Behind" 2001 legislation (NCLB). Unfortunately, the record indicates that implementation funds for NCLB are sorely missing. Although Congress authorized $450 million for the math and science partnerships program in 2002, it only appropriated $12.5 million. Three years later, the proposed total 2005 request for all math and science partnerships funding in both the Department of Education and the National Science Foundation is only $269 million. This still falls unreasonably short of its mark.

A National Education Association (NEA, 2002) shows ten year trends in education financing across state, local, and federal agencies that

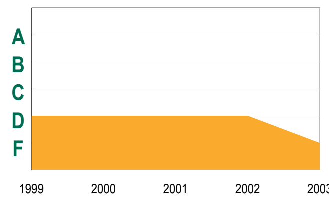
# Ranking of the States: Alabama

2003 Development Report Card for the States

## F Performance

| | | | |
|---|---|---|---|
| F | Employment | Employment Growth: Long Term | 43 |
| | | Employment Growth: Short Term | 45 |
| | | Unemployment Rate | 35 |
| | | Mass Layoffs | 48 |
| C | Earnings & Job Quality | Average Anuual Pay | 33 |
| | | Average Annual Pay Growth | 15 |
| | | Employer Health Coverage | 29 |
| | | Working Poor | 37 |
| | | Involuntary Part-Time Employment | 33 |
| C | Equity | Poverty Rate | 43 |
| | | Income Distribution | 43 |
| | | Income Distribution Change | 19 |
| | | Rural/Urban Disparity | 6 |
| C | Quality of Life | Net Migration | 33 |
| | | Infant Mortality | 49 |
| | | Uninsured Low Income Children | 15 |
| | | Teen Pregnancy | 41 |
| | | Deaths from Heart Disease | 41 |
| | | Homeownership Rate | 13 |
| | | Charitable Giving | 2 |
| | | Voting Rate | 20 |
| | | Crime Rate | 33 |
| D | Resource Efficiency | Per Capita Energy Consumption | 42 |
| | | Renewable Energy | 9 |
| | | Toxic Release Inventory | 40 |
| | | Recycling Rate | 29 |
| | | Vehicle Miles Traveled | 47 |
| | | Greenhouse Gas Emissions | 40 |

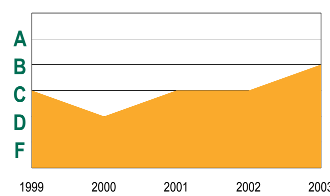
Performance History




## B Business Vitality

| | | | |
|---|---|---|---|
| A | Competitiveness of Existing Businesses | Strength of Traded Sector | 32 |
| | | Business Closings | 30 |
| | | Manufacturing Investment | 5 |
| | | Industrial Diversity | 1 |
| C | Entrepreneurial Energy | New Companies | 39 |
| | | Change in New Companies | 36 |
| | | Job Growth due to New Businesses | 26 |
| | | Technology Industry Employment | 22 |
| | | Initial Public Offerings | 16 |

Business Vitality History




## F Development Capacity

| | | | |
|---|---|---|---|
| D | Human Resources | Basic Educational Skills Proficiency-Reading | 36 |
| | | Basic Educational Skills Proficiency-Math | 35 |
| | | Average Teacher Salary | 25 |
| | | K-12 Education Expenditures | 38 |
| | | High School Completion | 46 |
| | | High School Attainment | 43 |
| | | College Attainment | 44 |
| C | Financial Resources | Dividends, Interest, and Rent | 42 |
| | | Venture Capital Investments | 34 |
| | | SBIC Financing | 28 |
| | | Loans to Small Business | 4 |
| D | Infrastructure Resources | Highway Deficiency | 17 |
| | | Bridge Deficiency | 36 |
| | | Urban Mass Transit | 45 |
| | | Sewage Treatment Needs | 15 |
| | | Electronic Public Services | 49 |
| D | Amenity Resources & Natural Capital | Energy Costs | 12 |
| | | Cost of Urban Housing | 10 |
| | | Health Professional Shortage Areas | 49 |
| | | Conversion of Cropland to Other Uses | 49 |
| | | Air Quality | 30 |
| C | Innovation Assets | Ph.D. Scientists & Engineers | 42 |
| | | Science/Engineering Grad.Students | 32 |
| | | Households with Computers | 49 |
| | | University Research & Development | 30 |
| | | Federal Research & Development | 5 |
| | | Private Research & Development | 38 |
| | | SBIR Grants | 21 |
| | | Royalties and Licenses | 25 |
| | | Patents Issued | 45 |
| | | University Spin-outs | 9 |

Development Capacity History

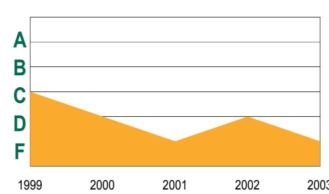



**Figure 1**

CFED
http://www.cfed.org
http://drc.cfed.org
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supports the claim that "No Child Left Behind" is an unfunded mandate (Figure 2). While state and local funding for education has been steadily climbing over the past ten years, federal funding has remained relatively flat. The NCLB accountability and assessment requirements have placed increasing pressure on States to perform these tasks and re-engineer the education process without additional funding support.

## WHAT ARE THE CHALLENGES IN STEM EDUCATION REFORM?

Reviews of national disaggregated data indicate that there are certain schools within our educational systems that are closing achievement gaps in STEM assessment areas despite issues of race, ethnicity, or socio-economic status. From these instances, the Education Trust (2003) has shared the following four elements that are present in all of these educational success stories. The outliers say:

1. They make no excuses. Everyone takes responsibility for student learning.
2. They build instructional systems that leave nothing about teaching and learning to chance.
3. High performing schools and districts insist on rigor all the way up the line.
4. They KNOW that good teachers matter more than anything else.

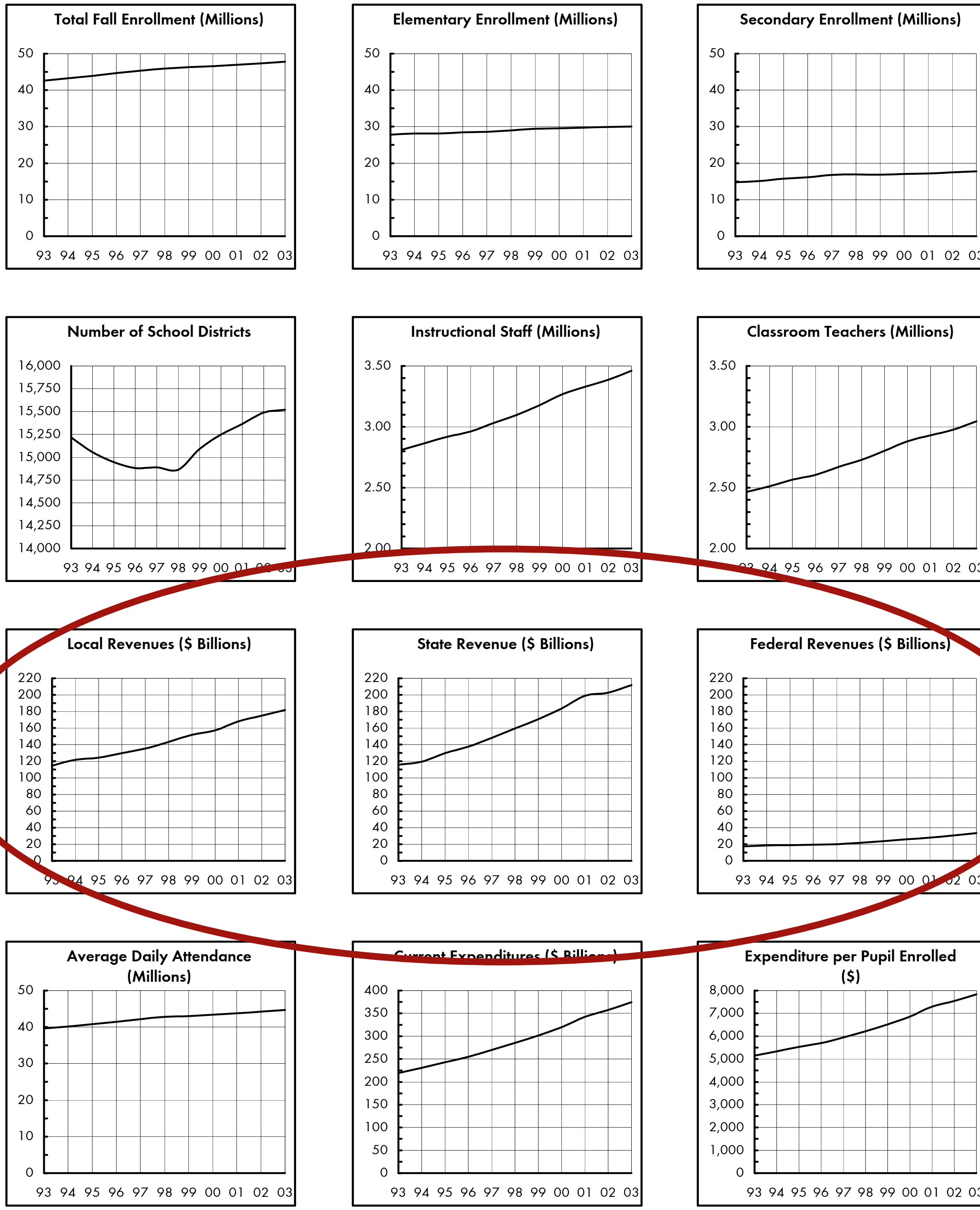
Alabama's educational system and its leadership have met and/or excelled in these four areas. The Education Trust (2003a) believes that a reliable instructional system includes:

- Common curriculum with specific learning goals at the end of each grade and key checkpoints during the year
- Support to help teachers teach that curriculum well including model lessons and aligned professional development opportunities
- Checkpoint assessments (e.g. 9 weeks) to monitor student progress
- Quick turn around data systems to put disaggregated results into teacher's and administrators' hands
- A reliable set of strategies for providing extra help to students who need it, including time/staff arrangements to support them

Alabama's Department of Education is continuously working to improve and refine the components used to define an outstanding and reliable instructional system. The Science Course of Study, slated for review this year, requires some consideration in its linkages to the National Science Education Standards in the earth and space science content areas. Alabama graduation requirements also appear weak in meeting the standards in these areas.

The primary perceived challenge for most citizens in Alabama is the budgetary constraints.

**Figure 2. Ten-Year Trends in Public Education Data, 1993–2003**



Budget deficits appear to be the focus of our biggest challenges. In past years, Alabama's D+ rating in funding has provided a B- return on its investment (Robinson, 2003). Although Alabama spends comparatively less on education that most states, ranking 41st out of 51 at $6,593 per student in the 2000-01 school year, it DOES dedicate 3.6% of its total taxable resources to education, which is just below the national average of 3.7% (EdWeek, Quality Counts, 2004). It provides a "fairly high share of state aid for education, ranking 12th in the nation." This data suggests that Alabama's diminished taxable resources (or its tax structure) have been fiscally compensated for by a proportionately larger and increased percentage on spending in education. This would likewise, suggest that the direct approach of asking taxpayers to pay a larger percentage of state funds for education does not address the real issue.

Other aspects of Alabama's education funding comparisons to total expenditures and to the national trend shows a remarkable 33% average annual growth in Alabama's higher education funding, while the nation's average is a mere 8% over the 1998 – 2002 timeframe (Education Trust, 2002, pg 9,13). The recent Governor's Commission on Education Spending Report calls for a reorganization of the Alabama Commission on Higher Education to "improve its ability to provide objective and relevant policy information to the Governor and Legislature". Alabama higher education is also being tasked to implement a report card to report on the performance of the Alabama colleges and universities systems[1]. K-12 funding equaled the national average of 6% average annual growth, but exceeded the nation's total expenditures by 5% - 11% and 6% for Alabama and the nation, respectively. However, the nation's average annual corrections to the budget were held to 7%, while Alabama experienced an 11% annual corrections rate.

But fiscal constraints in state education spending have not necessarily meant poor performance in K-12 systemic education reform. In

[1] The Alabama Math Science and Technology Education Coalition intends to follow up with a similar review and discussion of higher education activities in Alabama relevant to improving its functioning in systemic STEM education reform. Report cards for higher education are imperative to achieving success.

2003, the nation's most improved NAEP scores ($4^{th}$ grade math among others) from 1992 - 2000 (+25 points) occurred in North Carolina (Education Trust, 2003) (Table 1). In the 2004 EdWeek State-to-State Data Comparison (www.Edweek.org), North Carolina is within just 1/2 a letter grade for each area of comparison with Alabama, including both its adequacy and equity of resources categories.

***TABLE 1 - AFRICAN AMERICAN GAIN BETWEEN 1992 - 2000***

| States | 4th Grade Math | 8th Grade Math |
|---|---|---|
| North Carolina | +25 | +23 |
| Texas | +21 | |
| Massachusetts | +18 | |
| Illinois | | +22 |
| Ohio | | +22 |
| U.S. Avg. | +13 | +9 |

In only one of the five scoring areas North Carolina exceeded Alabama's rankings by a full letter grade; North Carolina's efforts to improve teacher quality scored a B, while Alabama scored a C (Table 2).

***TABLE 2 - ALABAMA AND NORTH CAROLINA COMPARISON***

| | Alabama | North Carolina |
|---|---|---|
| Student Acheivement | | |
| 4th grade NEAP math 2003 | 19% | 41% |
| 8th grade NEAP math 2003 | 16% | 32% |
| Standards & Accountability | B - | B |
| Efforts to Improve Teacher Quality | C | B |
| School Climate | C - | C + |
| Resources: Adequacy | C - | C |
| Resources: Equity | C - | C |

Notwithstanding the perceived challenges of budgets and resources, then it appears that Alabama can be a leader in systemic K-12 STEM education reform. It must, if the economy, government, and industry engines of Alabama are to continue to flourish and grow in the $21^{st}$ century.

## HOW IS ALABAMA'S STEM EDUCATION SYSTEM PERFORMING?

### 1. The System (in general)

Despite the tasks ahead of Alabama's education leaders and its legislature to make ends meet during the FY 2005 budget sessions, review of the past five years of education reform in Alabama compared with national trends shows Alabama has made good progress and even excelled in standards, assessment, reporting, professional development and teacher quality issues. "Arguably, the state's greatest strengths are its measures to hold teacher-preparation programs accountable for the performance of their graduates. The state is one of only 12"…that holds such an annual evaluation of pre-service program graduates (EdWeek, Quality Counts 2004). Elementary school class size has also been held to 18.7 pupils, besting the national average of 21.2 although the number of Alabama students per public school teacher overall has been increasing since 2000.

But further fiscal reductions and constraints to its education system could threaten to return Alabama to the days of "cotton-picking" and educational inequity for its citizens. Thirty-nine percent (39%) of Alabama schools have a building that needs extensive repair or should be replaced – 30% of the schools have crumbling roofs, 38% have bad plumbing, 26% have poor ventilation, and 63% have unsatisfactory environmental conditions. Moreover, one-third of Alabama's schools lack enough power outlets and wiring to accommodate computers and multimedia equipment in classrooms (ASCE, 2001). Yet, Science Highlights 2000 (NCES, 2002) shows statistically significant and higher scores in 4$^{th}$ and 8$^{th}$ grade science pupils who have used computers to play learning games (4$^{th}$) or make simulations and models (8$^{th}$)

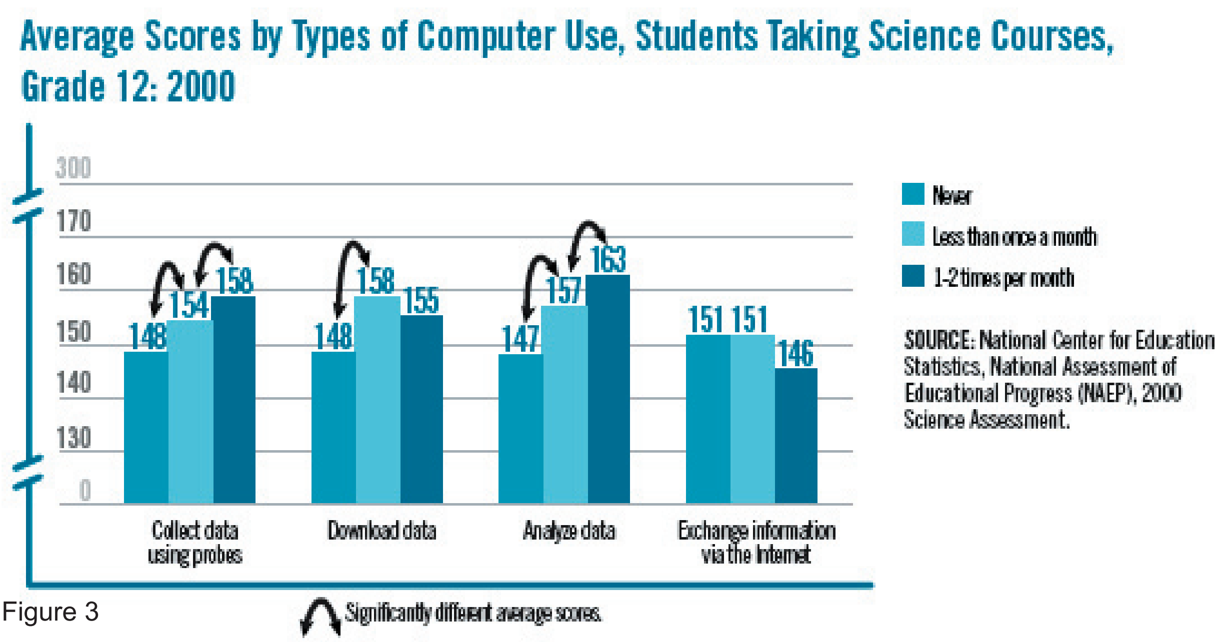



Figure 3

and analyze data ($8^{th}$) (ibid, 11). Moreover, by $12^{th}$ grade, (Figure 3) the statistically significant highest scoring students were those who reported more frequent (1-2 times per month) computer use undertaken to collect, download and analyze data. Finally, those students that reported less frequent computer use (less than once per month) scored significantly higher than those students that reported no computer use at all (ibid, 12).

As evidenced by the data, improving these conditions is extremely important in achieving science educational proficiency. New schools are often built with little architectural consideration given to our changing understanding of and our structural needs for inquiry-based science teaching and mathematics classrooms. Students and teachers who have been improving their scores in math and science assessments since 1990 deserve to be supported in developing Alabama's competitiveness in technological growth and high-tech industry expansion. One suggestion (Southeast Center for Teaching Quality, 2003, pg 2) includes helping educators to analyze the assessment data more comprehensively as a means to drive teacher development and student achievement. Other suggestions include specially funded professional development so that educators can use the information generated from the ratings.

Inquiry-based instruction in Alabama has a way to go both from the point of view of affecting higher education institutions' offerings and of altering the experience of students in STEM classroom instruction. Higher education institutions partnered with other non-profit, informal education facilities like the Explorium in Mobile, the McWane Center in Birmingham, and Sci-Quest in Huntsville, are working swiftly to establish and offer integrated inquiry-based courses. These progressive partners can, not only service the informal education community, but in some cases (like with the University of South Alabama and the Explorium) have begun to restructure STEM pre-service courses and to provide in-service teacher training. Yet it remains that student instruction across K-20 classrooms needs to transition from fact memorization and "fill out the summary sheet" static exercises to inquiry-based education. School administrators also require training in inquiry-based education, so they can understand and oversee classroom reform to ensure that STEM courses are delivered in a more timely and effective manner.

**2. The Students**

Three sources of assessment data are available for Alabama's math and science students:

- 2003 Stanford Achievement Test (SAT-10) results
- Alabama's High School Graduation Exam (AHSGE)
- National Assessment of Educational Progress (NAEP) tests performed by the National Center for Educational Statistics (NCES)

The NAEP data, commonly referred to as the Nation's Report Card, is also used by a number of organizations including the Education Trust and the National Education Association to compare and report state testing results. Alabama is one of only 21 states that have its NAEP assessment results disaggregated by race and socio-economic status (Figure 4).

The SAT-10 is a relative standard test where the average score across the nation is 50%. The 2003 SAT-10 was administered to Alabama's $3^{rd}$ - $8^{th}$ grades. The 2003 SAT-10 science test was administered only in grades 5 and 7. The SAT-10 results showed that Alabama's average in math and science was 49% and 56%, respectively; language (53%); reading (50%); and all subjects averaged 51%. An interesting observation of the SAT-10 results indicates that girls outperform boys. This is inconsistent with national trends in math and science gleaned from the NAEP results.

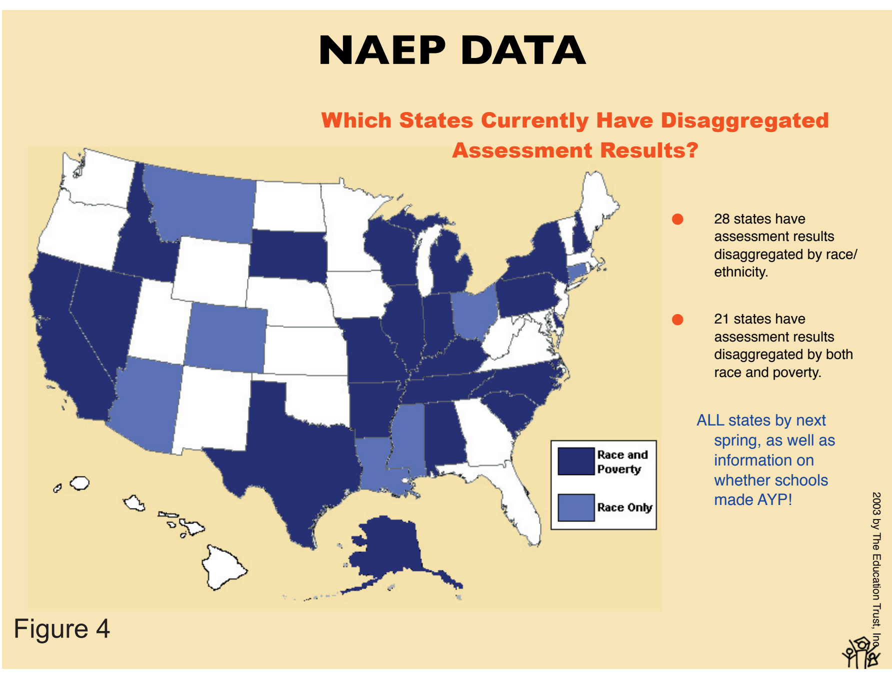



Figure 4

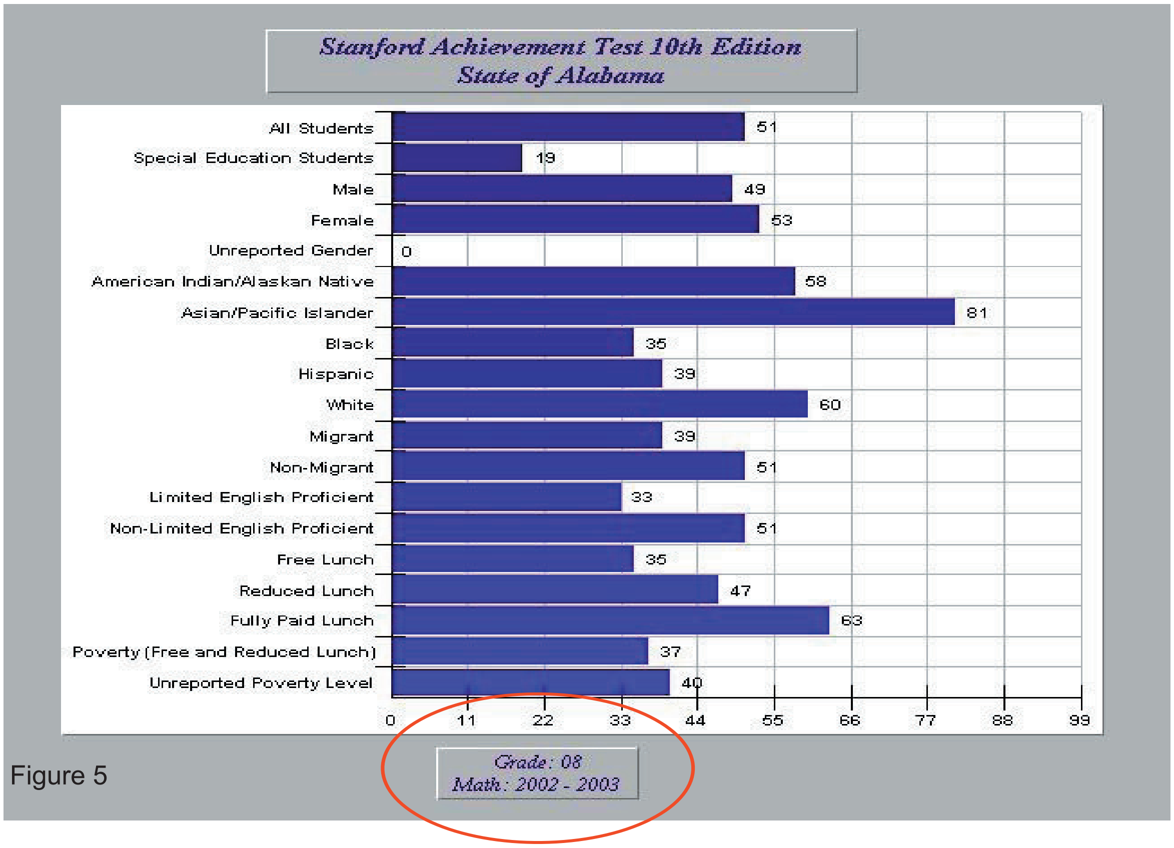



Figure 5

The disaggregated SAT-10 data show that Alabama is fairly average in its (poorer) performance of ethnic minorities and poverty groups (Figure 5). Asian students, in all cases, are outperforming all other groups, while the fully-paid-lunch group likewise performs well. Whites usually outperform Native Americans, Hispanics, and African Americans with a typical achievement gap of 20 percentage points. The achievement gap between poverty and fully paid lunches is typically higher in Alabama - on the order of 30 percentage points. These trends are consistent across all tested grades for math and science. The data also suggests that poverty is the bigger indicator of poor performance in math and science education in Alabama.

The Alabama High School Graduation Exam (AHSGE) was revised in 2001 and has continued to be administered each year in 10$^{th}$, 11$^{th}$ and 12$^{th}$ grades. Alabama boasts the highest graduating requirements in the nation - with this test being one of the most rigorous exams required for graduating, though the passing score requirement is relatively low. In 2000, the Fordham Foundation for Education ranked Alabama's standards-based, 4 by 4 curricula $5^{th}$ in the nation (meaning every high school student must take four years of English, Science, Social Studies and Math). This suggests that Alabama's Graduation Exam and its standards are among the best in the country.

Results from the High School Graduation Exams for math and science show that almost 97% of all students pass the $12^{th}$ grade. Similar findings in the disaggregated data exist for the AHSGE as for the SAT-10. However, the changes in performance from $11^{th}$ to $12^{th}$ grade show amazing closures in the achievement gaps that persist in the $11^{th}$ grade results (Figure 6). This trend alone supports the use of rigorous assessment to meet standards-based curricula. What is not evident from these results is the quality of the teaching style and the learning experience of the student during this interim. One can reasonably assume that teaching to tests is not the answer. If we can achieve and exceed these results using inquiry-based teaching and learning, then Alabama can claim a victory in STEM education reform.

The NAEP data exists for $8^{th}$ grade math since 1990 and was most recently administered in 2003 in $4^{th}$ and $8^{th}$ grades (Table 3). Scores on the whole are up since 1990 from 253 to 262 for $8^{th}$ grade representing a 78% increase in the proportion of $8^{th}$ graders scoring in the highest two levels in math. The total possible

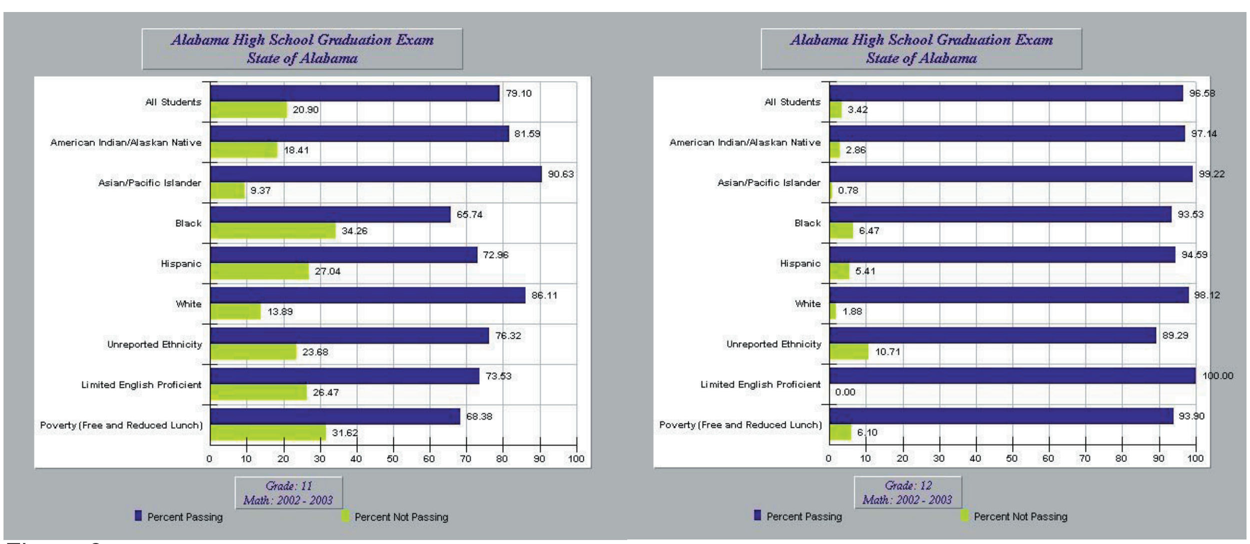



Figure 6

*Table 3*

## History of NAEP Participation and Performance

| Subject | Grade | Year | Scale Score: State Avg. | Scale Score: [Nat. Avg.]* | Achievement Level: Basic | Achievement Level: Percent at or Above Proficient | Achievement Level: Advanced |
|---|---|---|---|---|---|---|---|
| Mathematics (scale: 0-500) | 4 | 1992n | 208 | [219] | 43 | 10 | 0 |
| | | 1996n | 212 | [222] | 48 | 11 | 1 |
| | | 2000 | 217 | [224] | 55 | 13 | 1 |
| | | 2003 | 223 | [234] | 65 | 19 | 1 |
| | 8 | 1990n | 253 | [262] | 40 | 9 | 1 |
| | | 1992n | 252 | [267] | 39 | 10 | 1 |
| | | 1996n | 257 | [271] | 45 | 12 | 1 |
| | | 2000 | 264 | [272] | 53 | 16 | 2 |
| | | 2003 | 262 | [276] | 53 | 16 | 2 |
| Reading (scale: 0-500) | 4 | 1992n | 207 | [215] | 51 | 20 | 3 |

score is 500 but the national average was 262 and 276, respectively. The percentage of 8th grade students at or above the proficient level rose from 9% to 16% over the 13 year period leaving fifty-two percent (52%) of Alabama 8th graders performing at the basic level or above in 2003 (Figure 7).

Fourth grade math students' performance improved equally well over the 1992 – 2003 period. The state average score rose from 208 to 223 in conjunction with the national rise in average 4th grade math scores from 219 – 234. The percentage of 4th grade math students achieving at or above the proficient level rose from 10% to 19% in the 11 years since 4th grade math testing began. In summary, both 4th and 8th grade Alabama math students perform just below the national average but have shown significant improvement over the assessment period.

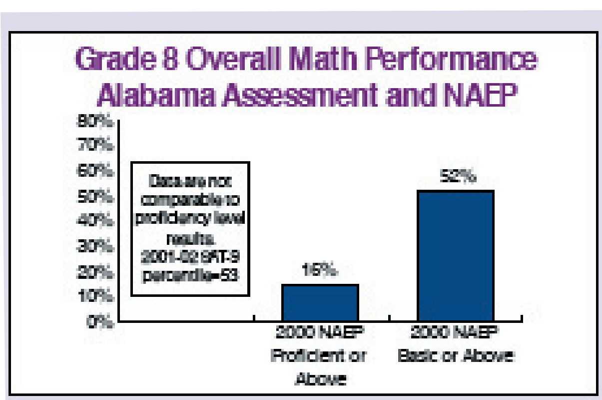



Figure 7

Results on 2003 gender differences indicate that males (263) outperform females (261) nationally by 2 points but score evenly within Alabama (223) (Figure 8). Whereas the 2003 achievement gap between Whites and Blacks in Alabama is lower (24 points) than the national average (34 points). Likewise, the average score of students

| Performance of NAEP Reporting Groups in Alabama | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Percentage | Average | Percentage of students at | | | | |
| Reporting groups | of students | Score | Below Basic | Basic | Proficient | Advan |
| Male | 51 | 263 | 45 | 37 | 16 | 2 |
| Female | 49 | 261 | 49 | 37 | 12 | 2 |
| White | 62 | 274 | 32 | 45 | 20 | 3 |
| Black | 36 | 240 | 73 | 24 | 3 | # |
| Hispanic | 1 | — | — | — | — | — |
| Asian/Pacific Islander | 1 | — | — | — | — | — |
| American Indian/Alaska Native | # | — | — | — | — | — |
| Free/reduced-price school lunch | | | | | | |
| Eligible | 47 ↑ | 246 | 65 | 29 | 6 | 1 |
| Not eligible | 53 | 276 | 32 | 45 | 21 | 3 |

Figure 8

not eligible for free/reduced lunch was 24 points higher than other Alabama students characterized as poverty-stricken. The national achievement gap between poverty-stricken and "not eligible for free lunch" students is 29 points indicating that in both cases, poverty is a prime indicator of poor mathematics proficiency albeit less pronounced in Alabama than it is in other states.

NAEP science testing began in 1996, and was administered to 8th grade Alabama students in 2000. Eighth grade science scores rose slightly since 1996 from 139 to 141, although the change was statistically insignificant (Table 4).

***Table 4. NAEP Science Testing Scores***

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Science (Scale : 0-300) | 4 | 2000 | 143 | 148 | 59 | 22 | 2 |
| | 8 | 1996 | 139 | 148 | 47 | 18 | 1 |
| | | 2000 | 141 | 149 | 51 | 22 | 2 |

The total possible score was 300 and the national average in 2000 was 149. Twenty-two percent (22%) of Alabama's 8th grade science students perform at or above the proficient level, while 51% perform at the basic level. Fourth grade science students have only been tested once in 2000. Results show that they performed below the national average (148) at 143 and with a similar 22% performing at or above the proficient level, with 59% performing at the basic level in 4th grade science.

Alabama is one of 12 (4th grade) and 15 (8th grade) states scoring below the national average in science. Nineteen (19) and 20 states respectively (Figure 9), scored higher than Alabama in 4th and 8th grade sciences out of 38 reporting. Seventeen (17) and 14 states reported scores not significantly different from Alabama's 4th and 8th grade science, while only 4 states (Mississippi, Louisiana, Hawaii, and California)

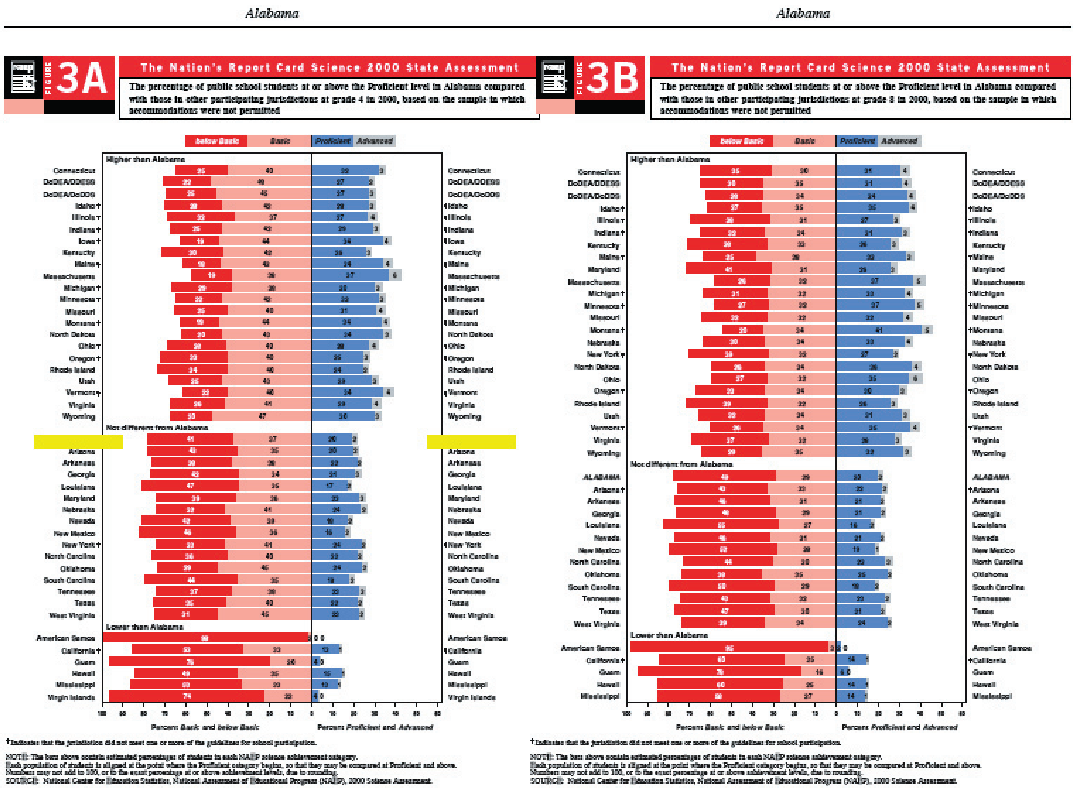



Figure 9

reported lower scores in 8th grade science and 3 states (Mississippi, Hawaii, and California) reported lower scores in 4th grade. Alabama's 2000 science and 2003 mathematics assessments suggest great differences in performance in the two subject areas. Future science assessments should be more telling for what progress may have been made in science since the 2000 assessment.

Differences in gender results show Alabama's boys and girls scored similarly (143) on the 2000 Science assessment (Table 5). Alabama males had an average lower than that of male students across the nation

***Table 5. Gender Differences***

**TABLE 2A — The Nation's Report Card Science 2000 State Assessment**

**Average science scale scores and achievement level results for public school students by gender at grade 4 for the sample in which accommodations were not permitted: 2000**

| | Percentage of Students | Average Scale Score | Below *Basic* | At or Above *Basic* | At or Above *Proficient* | *Advanced* |
|---|---|---|---|---|---|---|
| ***Male*** | | | | | | |
| 2000 Alabama | 51 ( 1.2) | 143 ( 2.3) | 40 ( 2.6) | 60 ( 2.6) | 23 ( 2.2) | 2 ( 0.5) |
| Nation | 50 ( 0.5) | 151 ( 1.0) | 33 ( 1.1) | 67 ( 1.1) | 31 ( 1.2) | 5 ( 0.5) |
| ***Female*** | | | | | | |
| 2000 Alabama | 49 ( 1.2) | 143 ( 1.8) | 42 ( 2.4) | 58 ( 2.4) | 21 ( 1.8) | 2 ( 0.5) |
| Nation | 50 ( 0.5) | 146 ( 0.9) | 38 ( 1.2) | 62 ( 1.2) | 24 ( 1.0) | 2 ( 0.4) |

NOTE: The NAEP science scale ranges from 0 to 300. The achievement levels correspond to the following points on the NAEP science scale at grade 4: *Basic*, 138–169; *Proficient*, 170–204; and *Advanced*, 205 and above. The standard errors of the statistics in the table appear in parentheses.
SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

***Table 6. Race/Ethnicity Differences***

**TABLE 3B — The Nation's Report Card Science 2000 State Assessment**

**Average science scale scores and achievement level results for public school students by race/ethnicity at grade 8 for the sample in which accommodations were not permitted: 1996 and 2000**

| | | | Percentage of Students | Average Scale Score | Below *Basic* | At or Above *Basic* | At or Above *Proficient* | *Advanced* |
|---|---|---|---|---|---|---|---|---|
| ***White*** | | | | | | | | |
| 2000 | Alabama | | 65 ( 2.2) | 154 ( 1.5) | 34 ( 2.0) | 66 ( 2.0) | 31 ( 1.9) | 3 ( 0.8) |
| | Nation | | 66 ( 0.3) | 160 ( 0.8) | 28 ( 1.0) | 72 ( 1.0) | 40 ( 1.1) | 5 ( 0.7) |
| 1996 | Alabama | | 61 ( 1.9) | 151 ( 1.5) | 37 ( 2.1) | 63 ( 2.1) | 25 ( 2.0) | 1 ( 0.6)* |
| | Nation | | 68 ( 0.4)* | 159 ( 1.1) | 28 ( 1.4) | 72 ( 1.4) | 36 ( 1.8) | 4 ( 0.8) |
| ***Black*** | | | | | | | | |
| 2000 | Alabama | | 28 ( 2.2) | 116 ( 2.4) | 80 ( 2.5) | 20 ( 2.5) | 4 ( 1.0) | 0 (****) |
| | Nation | | 14 ( 0.2) | 121 ( 1.3) | 76 ( 1.6) | 24 ( 1.6) | 6 ( 0.8) | 0 ( 0.2) |
| 1996 | Alabama | | 33 ( 1.9) | 117 ( 1.8) | 81 ( 1.9) | 19 ( 1.9) | 4 ( 1.1) | 0 (****) |
| | Nation | | 15 ( 0.3)* | 120 ( 1.2) | 77 ( 1.7) | 23 ( 1.7) | 4 ( 0.8) | 0 (****) |
| ***Hispanic*** | | | | | | | | |
| 2000 | Alabama | | 4 ( 0.5) | 106 ( 6.3) | 75 ( 5.6) | 25 ( 5.6) | 7 ( 3.8) | 1 (****) |
| | Nation | | 14 ( 0.2) | 127 ( 1.4) | 67 ( 1.7) | 33 ( 1.7) | 11 ( 1.2) | 1 ( 0.2) |
| 1996 | Alabama | | 4 ( 0.4) | 107 ( 7.6) | 80 ( 7.7) | 20 ( 7.7) | 7 ( 3.2) | 0 (****) |
| | Nation | | 12 ( 0.3)* | 127 ( 1.8) | 65 ( 2.3) | 35 ( 2.3) | 10 ( 1.2) | 0 (****) |

NOTE: The NAEP science scale ranges from 0 to 300. The achievement levels correspond to the following points on the NAEP science scale at grade 8: *Basic*, 143–169; *Proficient*, 170–207; and *Advanced*, 208 and above. The standard errors of the statistics in the table appear in parentheses. If the notation * appears, it signifies that this value is significantly different from the value for 2000.
**** Standard error estimates cannot be accurately determined.
SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 1996 and 2000 Science Assessments.

(151), but Alabama's female students did not score significantly different from that of female students nationwide (146). In terms of student composition, Alabama has the same percentage of males (51%) and females (49%) as the national averages. However, in its race/ethnicity comparisons (Table 6), Alabama has a higher than average Black composition (28% vs. 14%), lower than average Hispanic composition (4% vs. 14%), and average White composition (65% vs. 66%). Moreover, this trend in ethnic diversity is expected to continue to change for Alabama and the nation over the next two decades. The Census Bureau reported last summer that Latinos surpassed Blacks as the nation's largest minority, approaching 40 million resident in the United States (Figure 10). The changes and expected growth in our ethnic populations have concrete implications for addressing systemic STEM education reform and for closing the achievement gaps among Alabamian's and all citizens of the United States of America in the 21st century.

In the science achievement gaps related to race and ethnicity, Alabama Black and Hispanic 8th graders experience a greater gap than 4th grade science students. But, in general, the achievement gap between Whites and Blacks measures close to or greater than the national achievement gap, with 4th grade Whites in Alabama scoring 35 points higher than Blacks, who score 10 points higher than Hispanics. In comparison, the national achievement gap is characterized by White/Asians at the high end followed by a 20-point decline in scores to American Indians, fol-

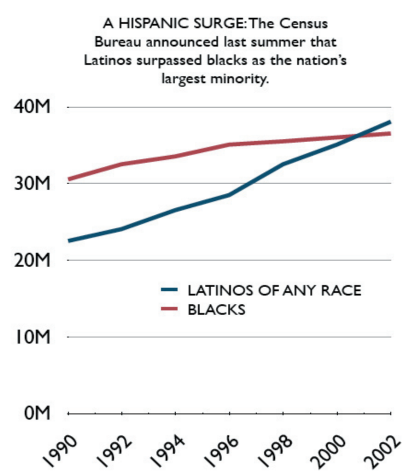


Figure 10

Percentage of Students at or above *Basic* and *Proficient* by Race/Ethnicity, Grades 4, 8, and 12: 1996–2000

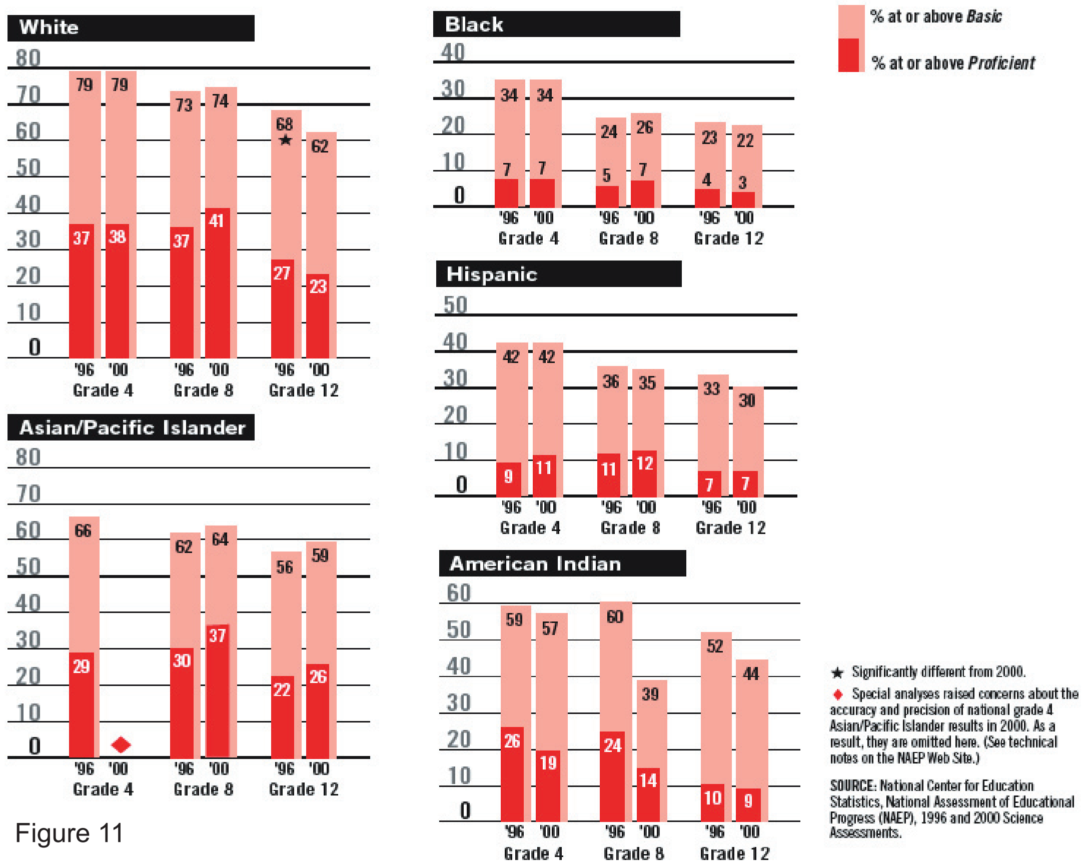



Figure 11

lowed by another 10-point decline for Hispanics, and concludes with another 3-point decline for Blacks (Figure 11). By 8th grade in Alabama, the achievement gap in science between Blacks and Whites has increased to 40 points. Note that 10 points equates to one full academic year of instruction in order to close such gaps in achievement between ethnic/income groups.

Science scores between students eligible for free/reduced lunch programs (128) versus those not eligible (159) indicate that Alabama's poverty-stricken students score consistent with other US poverty-stricken students (129 & 159), although Alabama has an appreciably greater percentage of students in the poverty status (Table 7). One-half of Alabama's students are eligible for free/reduced lunches in comparison to the national average of 37%. In Alabama 4th grade science students, only 9% who were eligible for free/reduced lunch scored at or above the proficient level in contrast to 36% of those

*Table 7 Income Differences*

**TABLE 4A** — The Nation's Report Card Science 2000 State Assessment

**Average science scale scores and achievement level results for public school students by eligibility for the free/reduced-price lunch program at grade 4 for the sample in which accommodations were not permitted: 2000**

| | Percentage of Students | Average Scale Score | Below *Basic* | At or Above *Basic* | At or Above *Proficient* | *Advanced* |
|---|---|---|---|---|---|---|
| ***Eligible*** | | | | | | |
| 2000 Alabama | 50 ( 2.2) | 128 ( 2.0) | 59 ( 2.5) | 41 ( 2.5) | 9 ( 1.5) | 0 ( 0.2) |
| Nation | 37 ( 1.1) | 129 ( 1.2) | 58 ( 1.3) | 42 ( 1.3) | 11 ( 0.7) | 1 ( 0.2) |
| ***Not Eligible*** | | | | | | |
| 2000 Alabama | 43 ( 2.5) | 159 ( 1.4) | 22 ( 1.8) | 78 ( 1.8) | 36 ( 2.0) | 4 ( 0.7) |
| Nation | 51 ( 1.9) | 159 ( 1.0) | 22 ( 1.1) | 78 ( 1.1) | 37 ( 1.4) | 5 ( 0.5) |
| ***Information Not Available*** | | | | | | |
| 2000 Alabama | 7 ( 2.3) | 146 ( 5.1)! | 36 ( 7.0)! | 64 ( 7.0)! | 23 ( 6.1)! | 1 ( 0.6)! |
| Nation | 12 ( 2.1) | 160 ( 2.4) | 22 ( 2.4) | 78 ( 2.4) | 39 ( 3.4) | 6 ( 1.7) |

NOTE: The NAEP science scale ranges from 0 to 300. The achievement levels correspond to the following points on the NAEP science scale at grade 4: *Basic*, 138–169; *Proficient*, 170–204; and *Advanced*, 205 and above. The standard errors of the statistics in the table appear in parentheses.
! Interpret with caution—the nature of the sample does not allow accurate determination of the variability of this statistic.
SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

who were not eligible. Similarly, in 8$^{th}$ grade, 9% and 31% indicate that, although the achievement gap between poverty and those not eligible for free/reduced lunch is still apparent, the gap is narrowing.

Alabama's composition of and scores from differing school environments shows some interesting trends also (Table 8). Although Alabama has a higher percentage of rural/small towns (15 percentage points higher) than the national average, its science test scores from those 142 locales are lower by 10 points. Alabama's lower percentage of urban fringe/large towns (16 percentage points lower) also score lower in science (148) by 5-8 points. City-center schools in Alabama and the nation score equally low (136) in comparison to the two other groups.

## 3. The Teachers

Alabama is ranked 11th on the current list of states with the most teachers certified by the National Board of Professional Teaching Standards (NBP, 2002 and NEA, 2002a) and among the top 10 states in the proportion of public school teachers who are nationally board certified. The state total is now 632 teachers, representing almost a ten-fold increase since 1999. The process for becoming nationally certified usually takes three years and requires teachers to:

- Show proficiency in their subject matter
- Evidence effective teaching strategies through portfolios, videotapes of lesson plans, and classroom performance
- Demonstrate their ability to manage and measure student achievement

Only 50 percent of teachers nationwide who

*Table 8. Community Differences*

TABLE 5A

**The Nation's Report Card Science 2000 State Assessment**

**Average science scale scores and achievement level results for public school students by type of community in which school is located at grades 4 and 8 for the sample in which accommodations were not permitted: 2000**

| | | Percentage of Students | Average Scale Score | Below *Basic* | At or Above *Basic* | At or Above *Proficient* | *Advanced* |
|---|---|---|---|---|---|---|---|
| ***Central City*** | | | | | | | |
| Grade 4 | Alabama | 30 ( 2.6) | 138 ( 2.8) | 48 ( 3.0) | 52 ( 3.0) | 19 ( 2.8) | 3 ( 0.7) |
| | Nation | 29 ( 1.5) | 137 ( 2.0) | 50 ( 2.4) | 50 ( 2.4) | 19 ( 1.6) | 2 ( 0.5) |
| Grade 8 | Alabama | 27 ( 1.6) | 134 ( 4.6) | 57 ( 4.8) | 43 ( 4.8) | 20 ( 2.9) | 2 ( 0.8) |
| | Nation | 28 ( 1.2) | 138 ( 1.9) | 54 ( 2.2) | 46 ( 2.2) | 21 ( 1.7) | 3 ( 0.6) |
| ***Urban Fringe/Large Town*** | | | | | | | |
| Grade 4 | Alabama | 28 ( 3.2) | 149 ( 2.5) | 34 ( 3.4) | 66 ( 3.4) | 28 ( 2.0) | 2 ( 0.7) |
| | Nation | 46 ( 2.4) | 154 ( 1.3) | 29 ( 1.5) | 71 ( 1.5) | 33 ( 1.5) | 4 ( 0.5) |
| Grade 8 | Alabama | 30 ( 1.8) | 148 ( 3.0) | 43 ( 4.0) | 57 ( 4.0) | 25 ( 3.7) | 3 ( 1.1) |
| | Nation | 45 ( 2.2) | 155 ( 1.2) | 35 ( 1.4) | 65 ( 1.4) | 35 ( 1.7) | 4 ( 0.7) |
| ***Rural/Small Town*** | | | | | | | |
| Grade 4 | Alabama | 42 ( 2.7) | 142 ( 2.7) | 42 ( 3.7) | 58 ( 3.7) | 19 ( 2.3) | 1 ( 0.6) |
| | Nation | 25 ( 2.1) | 152 ( 1.9) | 30 ( 2.1) | 70 ( 2.1) | 30 ( 2.3) | 3 ( 0.7) |
| Grade 8 | Alabama | 43 ( 1.8) | 142 ( 2.6) | 49 ( 3.0) | 51 ( 3.0) | 22 ( 2.0) | 2 ( 0.9) |
| | Nation | 27 ( 1.9) | 152 ( 1.8) | 38 ( 2.1) | 62 ( 2.1) | 33 ( 2.0) | 4 ( 0.7) |

NOTE: The NAEP science scale ranges from 0 to 300. The achievement levels correspond to the following points on the NAEP science scale at grade 4 (and 8): *Basic*, 138–169 (143–169); *Proficient*, 170–204 (170–207); and *Advanced*, 205 (208) and above. The standard errors of the statistics in the table appear in parentheses.
SOURCE: National Center for Education Statistics, National Assessment of Educational Progress (NAEP), 2000 Science Assessment.

attempt certification actually complete the process. In recognition of their achievement, board certified teachers in Alabama receive a $5,000 yearly bonus from the state for the 10-year duration of the certification.

In 1999, ninety-six percent of Alabama public secondary school teachers held a teaching certificate in their area of expertise giving Alabama one of the highest percentages in the country (NEG, 1999). A look at the number of classes taught by teachers lacking a major or a minor in the field yields a different result (Figure 12). Alabama averages almost a quarter (23%) of its secondary core classes being taught by teachers lacking either a major or a minor in the given subject.

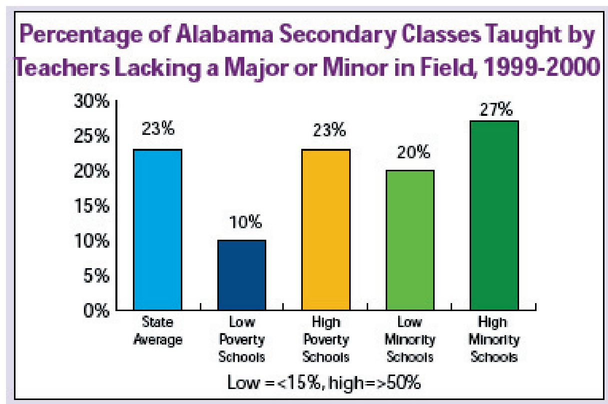



Figure 12

Nationally students in high poverty, high minority schools tend to receive less than their fair share of teacher talent. Math has been particularly impacted (Figure 13). The Education Trust (2003) cites research that math and science classes of mostly minority students are more often taught by misaligned teachers (Figure 14). This gives merit to Alabama's efforts to address teacher quality as a component of the "No Child Left Behind" legislation. Eighty-six

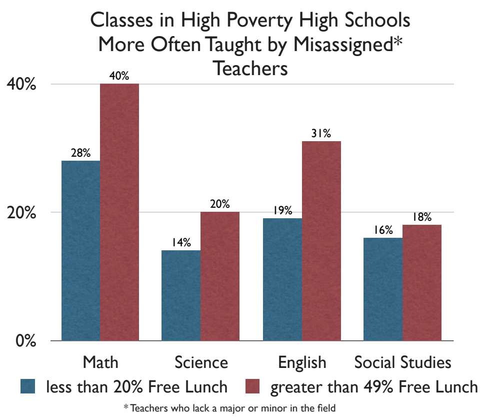



Figure 13

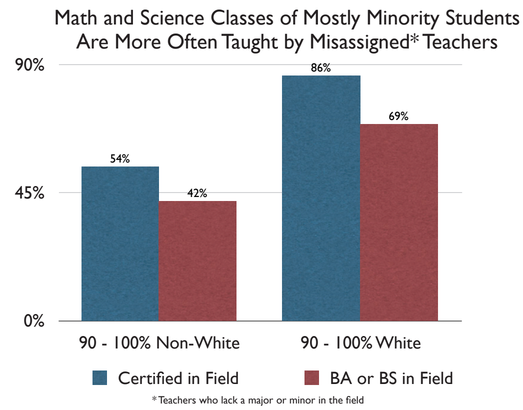



Figure 14

percent of Alabama public school teachers participated in in-service or professional development programs (ibid), another focus of NCLB. Alabama also ranks 5th out of the 50 states in the percentage of teachers that have a master's degree or higher (WMM, 1997).

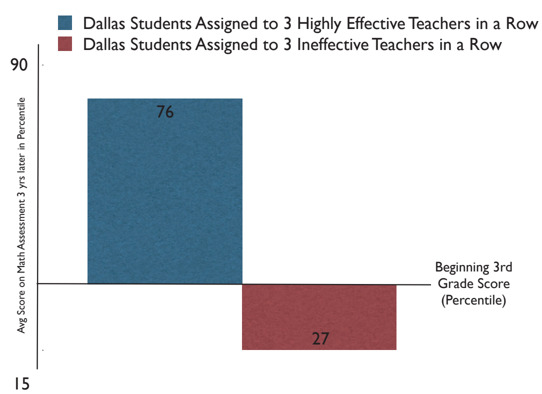



Figure 15

A 1997 Texas study on "Teacher Effects on Longitudinal Student Achievement" (Education Trust, 2003) quantified the difference in test scores between 3rd to 5th grade math students assigned to 3 highly effective teachers in a row (76 percentile) versus students assigned to 3 ineffective teachers in a row (27 percentile). The 2000 NAEP data on average scores by teachers' undergraduate major for 4th and 8th grade science shows another interesting and related fact (Figure 16). Teachers of science education were the only group with statistically significant differing average scores between those who majored in science (155) versus those who did not (151).

## WHAT HAS THE STAKEHOLDER COMMUNITY DONE TO ADDRESS ALABAMA'S NEEDS IN STEM EDUCATION?

The education and business communities, working together in the Alabama Math Science Technology Education Coalition and the

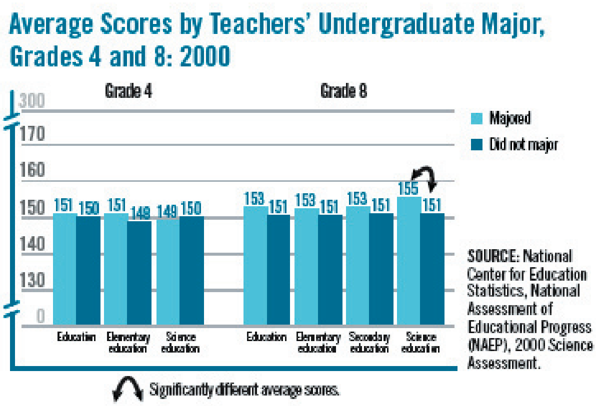



Figure 16

Alabama Department of Education (ADE), have developed a two-pronged approach for addressing Alabama's needs in STEM education. The first approach focuses on systemic STEM education reform and the second approach targets site-specific and near-term workforce development. The first program, the Alabama Math, Science and Technology Initiative (AMSTI), provides a long-term systemic approach to K-12 STEM education reform. Implementation began in 2002 with a well-researched and proven MAth, Science, Technology Education Resource (MASTER) site model (www.amsti.uah.edu).

The Governor's Commission on Education Spending just called for expansion of the Alabama Math, Science and Technology Education Initiative (AMSTI) in the "Student Assessment and Accountability Reforms for K-12 Education" section of its January 14th 2004 report. Eleven MASTER sites are planned to provide coverage across the state for complete K-12 implementation. A blue ribbon committee composed of K-12 educators, higher education representatives, and Alabama business leaders designed it. The committee's challenge was to design the most effective statewide initiative for improving math and science teaching. The plan's development over an 18 month period included:

- Examining data from international and national studies and state assessments
- Investigating national standards and their implications
- Reviewing STEM initiatives in other states
- Examining programs already being implemented in Alabama
- Reviewing Alabama courses of study and certification requirements
- Examining needs of business and industry
- Performing an extensive review of the literature
- Investigating the needs of Alabama teachers through a statewide survey

Three AMSTI MASTER sites are now located in Huntsville, Florence, and Mobile and serve over 50 North and South Alabama AMSTI Schools who have applied to the program. By the close of 2004, nearly 1,000 teachers will have been trained and supported through the AMSTI MASTER site model. Currently, funding for those three sites does not extend past May 2005. At the AMSTI MASTER sites, STEM educators are engaged in summer institute training over a two-year period. Instruction focuses on inquiry-based, hands-on teaching, using research-based curricula, developed with support of the National Science Foundation. Instruction also addresses the teacher's professional development needs such as deepening of content, improving instructional methods and techniques, implementing alternative assessments, and training on all equipment and resources that the teachers receive from the AMSTI MASTER sites (Figure 17). MASTER sites provide AMSTI teachers with all of the equipment, supplies, and resources they need to effectively engage their students effectively with hands-on, inquiry-based learning on a daily basis. Materials are kit-based and some include textbooks.


Figure 17

The ongoing support provided by MASTER site specialists who regularly visit AMSTI schools, teachers, and their classrooms has been synonymous with success in other national models for STEM education reform. AMSTI schools agree to designate one talented teacher in math and one in science to serve as site-based teacher leaders. These individuals receive additional training from the MASTER site and provide daily support for others in their schools, although currently they are not compensated for their additional work. These leaders also serve as key contacts for the MASTER math and science specialists visiting the schools. AMSTI schools are encouraged to provide release time for teachers serving as site-based leaders. Learning teams, sometimes referred to as study groups, are essential components of AMSTI. All AMSTI schools provide regularly scheduled sessions where teachers meet at their school, with guidance from the site- based leaders and MASTER site specialists, to address the school's AMSTI implementation issues. AMSTI Schools also schedule three days of follow-up AMSTI professional development during the school year.

AMSTI has established strong working partnerships with a number of other programs already in Alabama:

- **Global Observations to Benefit the Environment** (GLOBE) is a part of the AMSTI training. Through GLOBE in Alabama (www.globe.uah.edu), students perform environmental research and enter their data in databases that are used by scientists and other students around the world. In addition, students have access to the databases to conduct their own research thereby allowing GLOBE to provide the technology "glue" for the AMSTI program. In this way, AMSTI teachers and students are supported in their effort to use technology to collect, download, and analyze data about the world around them.
- **Alabama Science in Motion** (ASIM), a state-funded program in existence before AMSTI, is designed to provide public high school teachers with the equipment, inquiry-based training, and classroom support needed to run effective science laboratory programs. Each of the eleven ASIM sites supports two of the three major high school science disciplines: biology, chemistry, and physics. ASIM equipment includes research quality instrumentation and electronic data collection technologies (computers, programmable calculators, and hand held devices) used in laboratory activities which target Alabama Science Course of Study content standards. ASIM has been incorporated as the high school science component of AMSTI.
- **Alabama Technology In Motion** (ATIM) is a state funded program that assists schools with effectively using technology. ATIM specialists work with AMSTI schools to help implement many of the technological aspects of AMSTI, including GLOBE.

Efforts are being made to link AMSTI offerings to other successful programs in the state. Reading strategies promoted by the nationally acclaimed *Alabama Reading Initiative* are incorporated in instruction received by AMSTI schools. Many kits include relevant reading materials such as books in math and science. The GLOBE component of AMSTI is seeking to provide grade-appropriate reading materials for science to not only GLOBE schools, but to AMSTI and Reading First schools in Alabama as well.

A statewide Leadership Academy in Math, Science and Technology is also expanding at this year's summer institutes in consult with the Alabama Leadership Academy and the Alabama LASER (Leadership Assistance in Science Education Reform) team. LASER is a national science reform effort developed by the National Science Resources Center and sponsored in part by Dupont, Michelin, and Hewlett Packard (www.nsrc.online.org). Alabama LASER has also received contributions from local businesses such as Alabama Power and BellSouth to support district leadership team's attendance to Strategic Planning Institutes for training and planning in systemic science education reform.

However, systemic STEM education reform should be K-20 in breadth and efforts to see and experience the reform movement have been slow to take root and grow in Alabama's (and the nation's) institutions of higher education. Exceptions do exist, however; a recent National Science Foundation (NSF) award to Auburn University (www.team-math.net) for the implementation of a faculty and community-based math reform program, also the University of South Alabama's recent success to secure federal funding (via the ADE) for STEM faculty education. Alabama's Space Grant Consortium also has played a supportive role in systemic education reform across K-20 institutions in the state. Another NSF application was recently submitted by the University of West Alabama and Stillman College for faculty training and development of a 4th MASTER site to support integrated systemic STEM education reform in the much-needed black belt of West Alabama. But other budget-related challenges have presented themselves in the past. A competitive NSF application made by the Alabama Department of Education in 2003 was negatively reviewed and rejected for its lack of state support – namely for the purchase of appreciable instructional materials to implement the STEM reform initiative – a task NSF reviewers felt belonged to the state and not the funding agency.

The Alabama Math Science Technology Initiative (AMSTI) has been strategically developed and should be viewed as the cornerstone approach to implementing systemic K-12 STEM education reform in Alabama. But AMSTI is targeted at only one part of the audience for rectifying the long-term challenges in workforce development. Most discussions surrounding the need for workforce development – perhaps begun as a need to address immediate or near-term priorities – have ended up in a discussion about the need for a more systemic, or long-term approach to the challenges. Other programs like those being developed by the Alabama State Department's Career/Technical Division for specific industry partners (i.e. Mercedes, Honda, and Hyundai) and the Workforce Aging Management Program

(WAMP) in North Alabama and neighboring Tennessee (www.neinst.org) are addressing the more near-term needs of business and industry. The Governor's recent creation of a unified state "Office of Workforce Development" lends strength to the argument and need for focus on such efforts. In STEM education, one could argue that greater emphasis is needed, on systemic education reform as it relates to addressing the needs of business and industry through workforce development programs at the institutions of higher education.

## HOW DO WE PROPOSE TO CONTINUE TO IMPLEMENT SYSTEMIC STEM EDUCATION REFORM IN ALABAMA?

Further development of systemic STEM education reform in Alabama must drive forward from its good beginnings and build upon successes of other well-developed and expanding programs. Efforts must continue to provide a solid, long-term plan for offering leadership training to Alabama's school administrators and teachers in systemic STEM Education reform. Building upon the success of the Alabama Leadership Academy and the Leadership Assistance in Science Education Reform (LASER) programs to create the Alabama Leadership Academy for Math, Science and Technology is a good next step forward. Likewise, offering programs to get parents involved in and in support of STEM education reform at local AMSTI schools is a must. The FANS (Families Achieving New Standards in Math, Science and Technology Education) Project at Rutgers University and the National Network of Partnership Schools Program, part of the Center on School, Family and Community Partnerships at Johns Hopkins University, offer equally important models for future application in Alabama's schools and communities. Alabama must also continue to build on the requirements of NCLB and provide funding for professional development, teacher preparation, and better assessment/evaluation tools in our K-20 STEM classrooms.

This white paper has been developed as a tool for raising awareness about the issues surrounding STEM education reform and the existence of AMSTI and other associated STEM education reform programs in Alabama. The Alabama Math, Science and Technology Education Coalition (AMSTEC) seeks to extend its communicative efforts further towards public policymakers and business and industry representatives with the intention of fostering broad-based support for and awareness of AMSTI and other such programs that support it and its goals. All the while, AMSTEC shall continue to aid in the Alabama Department of Education's efforts to refine its offerings in systemic STEM education reform through improved assessment and evaluation of these programs.

Much has been accomplished in Alabama K-12 STEM education to support reform. AMSTEC has, through its member's institutions, identified the need and developed a model in systemic STEM education reform that builds on a locally testable pilot program that could be scaled nationally at a later time. Within this model, AMSTEC seeks to identify a number of non-traditional support roles with which business, industry, government and academia could assist the efforts towards K-20 systemic STEM education reform. They are, in addition to providing the traditionally desired financial support:

- Providing content specialists in professional development offerings,
- Implementing the use of STEM professionals as mentors and coaches to teachers and students in secondary education settings,
- Assisting with release time needs for classroom teachers,
- Providing release time and training for STEM professionals from government, business and industry to provide adjunct teaching services in secondary and undergraduate courses,
- Providing role models from business and industry from the under-represented minorities to encourage students to pursue careers in STEM professions, and
- Providing loaned executives to Alabama's educational systems in support of administrative and systemic STEM education reform efforts.

Improving the linkages between business and schools is not a new concept. The Business Council of Alabama's 2003 survey indicated that 77% of Alabama's businesses felt this concept was important or very important. In May 2003, Bayer Corporation released results from a Gallup survey (Gallup, 2003) indicating that nine in ten Americans believe that improving pre-college math and science education is a national priority that must be addressed and they believed that business and industry have a valuable role to play in that effort. The Bayer survey responses to "What kinds of programs were valued?" were:

- 98% said company employee-volunteer programs that bring scientists, engineers and technical workers into the classroom to work with students and teachers
- 98% said internship programs for high-school students that bring students into companies to interact with scientists, engineers, and technicians
- 96% said internship programs for K-12

science teachers that bring the teachers into companies to interact with scientists, engineers and technicians

- 95% said one-on-one mentoring programs for middle and high school students

AMSTEC also has intentions of increasing the role of retiring business and industry representatives in STEM education reform by building upon the success the National Academies Project RE-SEED, Retirees Enhancing Science Education through Experiments and Demonstrations (www.reseed.neu.edu). Retirees are required to take 12 days or about 66 class hours of training before being matched with a teacher-partner and students in actual schools. The focus is less on the pre-existing content knowledge of the retirees and more on pedagogical questions and research on how children learn. The founders of RE-SEED, Drs. Alan Cromer and Christos Zahopoulos of Northeastern University, are also founders of Project SEED, designed to teach middle school physical science teachers inquiry-centered, activity-based approaches. Project RE-SEED is expanding to new sites across the country and abroad (Atlanta; Denver; Portland; Oregon; and Stockholm) so extending that model into Alabama has strong possibilities, given AMSTEC's partnership model which includes NASA and its aging workforce issues.

NASA currently employs over 7,000 employees and on-site contractors at its Alabama facilities at Marshall Space Flight Center (MSFC). NASA/MSFC's employees average age is 46 and NASA estimates that 25% of its workforce is eligible to retire in the next 5 years. NASA is not alone in this dilemma. NASA/MSFC, in cooperation with its regional partners via a Tri-lateral Alliance, the Department of Energy (Oakridge National Labs and Y-12), and the Department of the Air Force (Arnold Engineering Development Center) in Tennessee, are seeking to coordinate their efforts to support systemic STEM education reform and workforce development in the valley corridor (www.orau.gov/trilateralalliance). While the WAMP initiative is focused on the near-term workforce development issues, AMSTEC's model for partnership support as presented by the National Space Science and Technology Center (NSSTC), has provided the focus for discussions and planning for how these tri-lateral alliance agencies may go about participating in a regional systemic STEM education reform effort. This model builds upon the successes of the GLOBE in Alabama program for

K-12 and the Alabama Space Grant Consortium for higher education to support systemic K-20 STEM education reform.

AMSTEC's origins began with its founding in a NASA-sponsored program called "Linking Leaders" and its continued growth in the context of NASA's trilateral alliance partnerships seems equally likely. NASA/MSFC's leadership role in the state is unprecedented and evidenced by the Governors recent announcement of the Alabama Space Exploration Initiative. The recent five-year program performance and results report of the Alabama Space Grant Consortium states it well:

> "While some states have large NASA centers, most of the states (California, Florida, Ohio and Texas) are much larger in population and industrial production terms, or as in the case of Maryland and Virginia, the impact of NASA is overwhelmed by much larger government presences. Since the early days of Redstone and Apollo Rockets, the people of Alabama have looked to Marshall Space Flight Center (MSFC) as a focus for development of high technology industry in the State and for involvement of its universities in space science and engineering. Clear evidence of this is given by the growth of Cummings Research Park, adjoining MSFC in Huntsville, the second largest park of its kind in the US and the fact that Alabama universities rank sixth in the US in terms of NASA grants and contracts to the state." (Gregory, 2003, 6)

NASA continues to support AMSTEC today and its Executive Director office is now co-located at the National Space Science and Technology Center (NSSTC) in the same facility as the NASA/MSFC Education Programs Department Offices. NSSTC is an existing partnership in Alabama between government, business and academia. Its university partnerships are comprised of the Space Science and Technology Alliance (SSTA) universities, Alabama's seven PhD granting institutions of higher education in space and earth sciences. NSSTC and its SSTA network are uniquely positioned to address the call of the Governor in the Alabama Space Exploration Initiative with respect to "strengthening our capabilities in support of our nation's new space policy." Systemic K-20 STEM education reform is an imperative in that process.

To that end, NSSTC's Office of Education and Public Outreach, in conjunction with AMSTEC, the Alabama State Department of Education, and the Alabama Space Grant Consortium, have developed a partnership model for addressing the needs of systemic STEM education reform in the State of Alabama's AMSTI schools (Figure 18). It offers an implementation network across Alabama's higher education institutions for addressing the needs of K-20 STEM education reform. It builds upon Space Grant's unique cadre of university engineers and scientists who are enthusiastic, motivated technical mentors already in place across the SSTA network. Through dialogue and inclusion of business/industry needs in the planning, this partnership of business, academia, and government can implement Alabama's effective STEM education reform and workforce development programs. But even successful schools still will have a way to go before management gurus readily cite them as benchmarks against which other organization's leaders want to measure themselves. AMSTEC envisions that one day, great schools will be more businesslike just as great businesses are increasingly more school-like. It is this balance of business, industry, academia and government in support of education for which systemic STEM education reform calls.

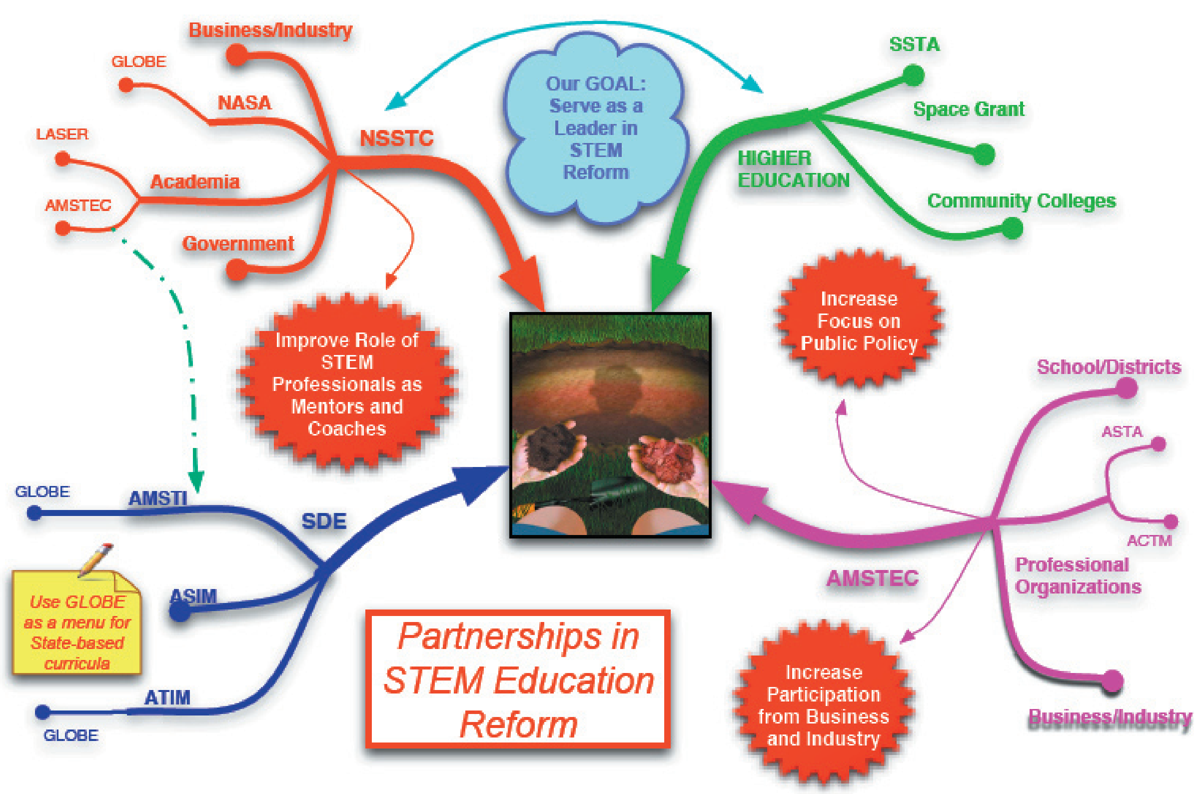



Figure 18

## WHAT CAN YOU DO TO SUPPORT STEM EDUCATION REFORM?

Lester Thurow, former Dean of M.I.T.'s Sloan School of Management stressed there will be a historic movement in wealth away from nations with natural resources and capital. "In the 21st century", he said, "Brainpower and imagination, invention, and the organization of new technologies are the key strategic ingredients." If we consider this notion and these facts - that the class of 2016 enters kindergarten this fall and that the class of 2021 was born this year - then we can begin to see that programs and initiatives implemented now will impact and strengthen the next generation of learners and business leaders.

We are building for the future. We cannot back down on our education goals and we must continue to audacious ones if we want to be great. We are preparing our children to accomplish their individual dreams, and to meet the challenges of the changing economy. The higher standards the state Board of Education has set, and the use of accountability instruments like NAEP, help to keep the citizens and policymakers of Alabama informed on the progress of education in our state.

***If you are an educator or already involved in and aware of systemic STEM education reform……***
"Never, never, never, never, never give up!" to quote the keynote speaker, Dr. Ed Richardson, at the 2003 Alabama Science Teachers' Association meeting who quoted the original speaker of those words, Winston Churchill.

***If you are a parent or grandparent….***get involved with you local school and district administrators to learn what is happening in your schools. School officials in Alabama are more likely to report that a lack of parent involvement is a problem in their schools than in the average public school in the nation (EdWeek, Quality Counts 2004). Systemic STEM education reform calls for a broad community-based program of support that includes parents, teachers, administrators, and local business and industry participation. Contact the NSSTC EP/O office to find out about community involvement programs being offered in your area.

***If you are a STEM business/industry repre-***

***sentativ**e*…..join AMSTEC and find ways for your company to become involved in systemic STEM education reform efforts in your community, region, or state. Contact your local chamber of commerce and ask about ways your company could become involved in STEM education reform programs in your area.

***If you are a policymaker*** ….become aware of the national need or crisis in science and technology literacy and the impact that preparing (or not preparing) our citizens will have on Alabama's future economic development. Having taken steps towards that in reading this report, support legislation to coordinate systemic STEM education reform efforts through the partnership model proposed by AMSTEC in conjunction with the Alabama Department of Education. If you have any questions, contact AMSTEC (www.amstec.org) and request a presentation about systemic STEM education reform from a local member/constiuent

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## Acronyms

ADE - Alabama Department of Education

AHSGE - Alabama's High School Graduation Exam

AMSTEC - Alabama Mathematics, Science, and Technology Education Coalition

AMSTI - Alabama Math, Science and Technology Education Initiative

ASCE - American Society of Civil Engineers

ASIM - Alabama Science in Motion

ATIM - Alabama Technology In Motion

FANS – Families Achieving New Standards in Match, Science, and Technology Education

LASER - Leadership Assistance in Science Education Reform

MASTER - MAth, Science, Technology Education Resource

MSFC – Marshall Space Flight Center located in Huntsville, AL, a division of NASA.

NAEP - National Assessment of Educational Progress

NASA – National Aeronautics and Space Administration

NCES - National Center for Educational Statistics

NCLB - No Child Left Behind

NCTM – National Council of Teachers of Mathematics

NEA - National Education Association

NRC – National Research Council

NSES - National Science Education Standards

NSF - National Science Foundation

NSRC – National Science Resources Center

NSSTC – National Space Science and Technology Center

NSTA – National Science Teachers Association

RE-SEED – Retirees Enhancing Science Education through Experiments and Demonstrations

SAT - Stanford Achievement Test

SSTA – Space Science and Technology Alliance

STEM - Science, Technology, Engineering, and Math

TIMMS – Trends in International Math and Science Study

WAMP - Workforce Aging Management Program